Investigating Environmental-related Deaths

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Environmental-related Deaths

- Drowning
- Hyperthermia
- Hypothermia
- Lightning-related fatalities

Drowning

- *Drowning is a process of experiencing respiratory impairment from submersion/immersion in a liquid.*
- 4000 fatal accidental drownings per year in the U.S.
- 10 deaths per day in the United States.
- 5th leading cause of accidental death for all ages.
  - 2nd leading cause of accidental death for children ages 1-14 years.
  - All children 1-4 years who died, 30% died from drowning.
- IOSME - 2020
  - 31 drowning deaths (3%).

Factors Common to Drowning Incidents

- Age: Toddlers and Teenage boys.
- Race: Black children at higher risk.
- Gender: Males > Females.
- Location: Bathtubs, buckets, toilets, swimming pools, lakes, ponds, rivers
- Drugs: Particularly alcohols.
- Preexisting disease: Cardiac and neurological conditions.

Drowning - Investigation

- Consider when:
  - Body recovered from water.
  - Body found near a body of water or bathtub.
  - Head submerged in liquid.
- Manner of Death
  - Accident
  - Natural
  - Suicide
  - Homicide
  - Undetermined

Drowning - Investigation

- Dx of exclusion
- Requires:
  - Knowledge of decedent
  - Circumstances surrounding death
  - Scene investigation
  - Autopsy
  - Toxicology/ Carbon monoxide

Investigation – Pools and Bodies of Water

- How / Why did the person get in the water?
- Was person alive or dead prior to entry into the water?
- Why was the person unable to survive in the water?
  - Human factors
  - Env't factors
  - Equipment factors (if applicable)
- Did the person drown?
- Swimming pools
  - Any electrical devices / underwater lighting.
  - Life guards/ Other witnesses
  - Video Surveillance.
  - Children – how did they gain access to pool?

Bathtub Drowning

- Rare in adults.
  - Associated with debilitation leading to unconsciousness.
    - Disease, drugs, trauma.
  - Homicidal drowning vs Homicide dump.
  - "Bathtub resuscitation."
- More common in infants and small children.
- Many deaths in bathtub are due to causes unrelated to the bath or drowning.

Investigation – Bathtubs

- Is water in the tub?
  - Temperature of water.
  - Depth of water.
  - Did finder drain the water? Does drain work?
  - Presence of water line?
- What is the position of the body in the tub?
  - Is airway submerged underwater?
- If body out of tub:
  - Is decedent / bathtub / floor / person who found decedent wet?
- Electrical devices near bath tub?

Autopsy - Drowning

- No "drowning test".
- "Foam cone".
- Hyperinflated lungs (emphysema aquosum).
- Fluid in sphenoid sinus.
- Wrinkling of the skin of palms of hands and soles of feet.
- Fluid and debris in respiratory tree.
- Fluid and debris in gastrointestinal tract.
- Mastoid air cell hemorrhage.
- Debris
- Trauma.
  - Antemortem vs postmortem
  - Cervical Spinal Cord Injury?

Autopsy – Artifacts from Immersion in Water

- Postmortem Scavengers.
- Decomposition.
- Postmortem trauma.

Disproved Markers of Drowning

- Diatoms present in organs/bone marrow
- Electrolytes differences b/w Rt heart and Lt Heart
- Sphenoid sinus fluid

Hypothermia a Contributing Factor?

- Water at 91.4 F is thermally neutral.
  - Heat loss = heat production for swimmer without clothes.
  - Water colder than this leads to heat loss.

Water Temperature	Expected Survival Time
70-80 F	3 hr – indefinitely
60-70 F	2-40 hr
50-60 F	1-6 hr
40-50 F	1-3 hr
32.5 F–40 F	30-90 min
< 32 F	< 15-45 min

Hypothermia and Hyperthermia

Hypothermia

- *Hypothermia is an decrease of core body temperature below the normal diurnal range of 36 - 37.5°C (96.8 - 99.5 °F).*
- Heat produced or absorbed < Heat lost to environment.
- Heat loss by the body (sitting at room temperature):
  - Radiation (65%).
  - Evaporation (30%).
  - Conduction and Convection (5%).
  - Respiration.

Hypothermia

- Primary means of staying warm in cold environment:
  - Shunting of blood from shell to core.
  - Shivering.
  - Getting out of cold environment.
  - Warm clothes/ blankets.

Hypothermia

Decreased Heat Production

- Insufficient Fuel.
  - Malnutrition.
  - Fatigue.
- Age Extremes.
- Decreased muscle mass.
- Barbiturates.
- Hypothyroidism.
- Genetic predisposition.
- Previous cold injury.
- Alcohol.

Increased Heat Loss

- Environmental temperature.
- Cold water immersion.
- Lack of clothing/wet clothing.
- Thin subQ fat layer.
- Heavy exercise/immobility.

Physiological changes in Hypothermia

- 89.6 °F - impairment of cerebral function.
- 89.6 - 84.2 °F - shivering ceases, HR decreases, RR decreases.
- < 84.2 °F - hypothalamic regulation of body temperature stops.
- *Body temperature < 86 °F has 70% mortality.*

Local physiological changes to the cold

- Initially arterial constriction followed by vasodilatation in 10-15 minutes.
- Sludging of RBCs and stasis.
- Edema.
- Tissue ischemia.

Hypothermia - Investigation

- Consider when:
  - Any body recovered from water.
  - Any individual found outdoors in cold environment without life-threatening traumatic injuries.
  - Older individuals found outdoors during cooler months.
  - Older individuals found indoors with no heat source or utilities have been shut off.

Hypothermia - Investigation

- Diagnosis of exclusion.
- Temperature range – LKA to time found.
  - If indoors:
    - Has thermostat been changed.
    - Other means of staying warm (space heater, blankets, coats).
- Is body frozen.
- Paradoxical undressing (50-70%).
- Terminal burrowing (25%).
- Condition of ground under body.
- Risk factors
  - Age, PmHx, EtOH, Drugs, Nicotine, Appropriately dressed, Body/Clothing wet, Fatigue.

Autopsy

- No pathognomonic findings.
- Body is often frozen.
- Cherry red lividity.
- Frostbite-like erythema of elbows, knees – 76%.
- Abrasions on hands, elbows, feet, elbows.
- Gastric lesions (Wischnewsky spots) – 90%.

Autopsy

- Hemorrhagic pancreatitis.
- Hemorrhages of intestines, iliopsoas muscle (5-37%), synovial membrane (67-75%).
- Lipid accumulation in heart, liver, kidney, skeletal muscle.
- Cardiac muscle degeneration.
- Elevated urinary catecholamines.
- Vitreous studies: Elevated glucose.

Hyperthermia

- *Hyperthermia is an elevation of core body temperature above the normal diurnal range of 36 - 37.5°C (96.8 - 99.5 °F).*
- Heat produced or absorbed > heat lost to environment.
- Heat loss by the body (sitting at room temperature):
  - Radiation (65%).
  - Conduction and Convection (5%). } Only occurs if Core Body Temp > Envt Temp
  - Evaporation (30%).
    - Minimal if humidity > 80%.
  - Respiration.

Hyperthermia

- Primary means of staying cool in warm environment:
  - Getting out of warm environment.
  - Wearing lighter/less clothing.
  - Sweating (requires evaporation of sweat).
  - Cutaneous vasodilatation.

Hyperthermia

Increased Heat Production

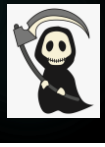
- Physical Activity.
- Pharmacological agents.
  - Amphetamines, cocaine, LSD, PCP.
  - Antipsychotic medications (neuroleptic malignant syndrome).
  - Anesthetic gases (malignant hyperthermia).
- Natural disease.
  - Seizures.
  - Pheochromocytoma.
  - Thyrotoxicosis.

Decreased Heat Loss

- High Env't Temperature and High Humidity.
- Dehydration.
- Natural Disease.
  - Cardiovascular disease.
  - Obesity.
  - Skin Diseases.
- Lack of acclimatization.
- Clothing.
- Extremes of Age.
- Medications.
  - Anticholinergic type effects.
    - TCA
    - Antidepressants.
    - Antihistamines.
  - Diuretics.

Pathophysiology of hyperthermia

- Core body T ↑ → Cell damage → Inflammatory response
- Blood shunted to peripheral circulation/sweating → Organ hypoperfusion → Ischemia → Organ failure and DIC



Continuum of heat-related illness

- Heat edema: Swelling in hands and feet; body temperature not increased.
- Heat cramps: painful, brief muscle spasms. Usually involve muscles fatigued by exercise.
- Heat rash: blocked eccrine sweat glands.
- Heat exhaustion: thirst, nausea, vomiting, headache, dehydration, hypotension, tachycardia, dizziness, fainting.
  - Body temperature: 100 °F - 104 °F.
- Heat stroke: Heat exhaustion + CNS dysfunction (confusion, delirium, altered consciousness, seizure, coma), end organ damage, +/- sweating
  - Body temperature: > 104 °F.

Hyperthermia - Investigation

- Consider when:
  - Young individuals undergoing extreme exertion.
  - Older individuals in summer months.
  - Older individuals whose utilities have been shut off.
  - Children left unattended in vehicles on warm days.

Vehicle temperature vs Outside air

Vehicle temperature vs Outside air

Elapsed time	Outside Air Temperature (F)					
	70	75	80	85	90	95
0 minutes	70	75	80	85	90	95
10 minutes	89	94	99	104	109	114
20 minutes	99	104	109	114	119	124
30 minutes	104	109	114	119	124	129
40 minutes	108	113	118	123	128	133
50 minutes	111	116	121	126	131	136
60 minutes	113	118	123	128	133	138
> 1 hour	115	120	125	130	135	140

Hyperthermia - Investigation

- Diagnosis of exclusion.
- Temperature range – LKA to time found.
- If in residence:
  - Air conditioning? Is it working?
  - Windows/doors open?
  - Alternative sources of cooling?
- Humidity.
- Rectal temperature.
- Reconstruct dec'd activities prior to death.
  - Signs of heat exhaustion (N/V, HA, fainting)
- Other risk factors
  - Age, PmHx, Meds, Illicit Drugs, Clothing

Autopsy Findings

- Hyperthermia death is due to cardiac dysrhythmia, seizure or shock.
- Gross and microscopic autopsy findings are non-specific.
  - Survival > 24 hrs may see centrilobular necrosis in liver, ATN, loss of Purkinjie cells, adrenal necrosis, myocardial infarct.
- Vitreous electrolytes may show a dehydration pattern.
  - Increased sodium, chloride, urea nitrogen, +/- creatinine.

Lightning: Overview

- 100,000,000 volts
- 30,000 amps
- 1000 gigawatts
- 53,000 Fahrenheit
- 270,000 mph
- 44 strikes/second

Lightning: Overview

- 100 persons killed/year in U.S.
- Most strikes occur during thunderstorms.
  - 10% when skies are blue.
- Majority occur in outdoors in summer.
- Men > Women.
- Age: < 16 yo and adults 26-35 yo.
- About 1/3 of lightning strikes are fatal.

Lightning: Myths

- Metal attracts lightning.
- Cell phones, iPods, head phones increase the risk of injury.
- Being inside a fully enclosed metal vehicle is unsafe.
- Okay to swim indoors.
- Lightning always strike the tallest object.
- Lightning victims are electrified.

Lightning strikes:

- Direct strike (3-5%)
- Indirect strike
  - Side flash from object (30%)
  - Contact voltage (1-2%)
    - Water pipe (bathtub/shower) or wire (telephone) acts as conduit
  - Ground current effect (40-50%)
  - Blunt trauma (10%)

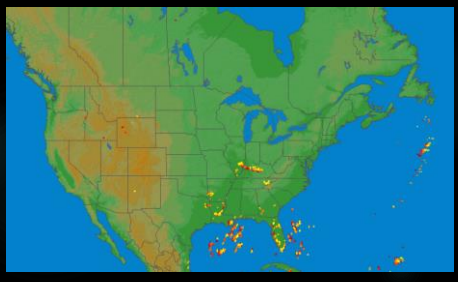
Lightning causes injury by:

- Light
- Heat
- Electricity
- Barotrauma

Scene findings

- Scorching of nearby objects, fusion of metal objects, blast effects.
- Clothing defects (tears, burns burst shoes, nudity) - can simulate rape or other assault.
- Magnetization of metal items at scene/on victim.
- Keraunographical marks.

Lightningmaps.org

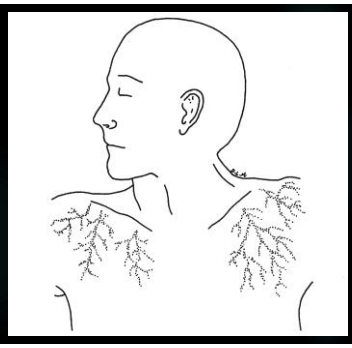


Autopsy findings

- Development of early rigor or regional rigor.
- Singeing of hair.
- Variable burn patterns .
  - Less than 1/3 have burns (usually superficial).
- Separation of epidermis and dermis.
- "Tip toe" sign – blow out laceration on soles of feet/shoes.
- Rupture of eardrums (80%).
- Rupture of GI tract and lungs.
- Blunt trauma.
- Lichtenberg figure (33%).

Lichtenberg figure

- Fern-like mark on some victims.
- Unique to lightning strikes.
- Not known why it forms.
- Mark may not appear right away, generally fade within 24 hours.



Mechanisms of death

- Immediate cardiorespiratory arrest.
- Electrothermal injuries.
- Secondary trauma.
  - Fall.
  - Struck by object.

END